
Peperiksaan Semester Pertama
Sidang Akademik 2005/2006
*First Semester Examination
2005/2006 Academic Session*

November 2005
November 2005

ESA 251/3 – Teori Sistem Kawalan
Theory of Control System

Masa : 3 jam
Duration : 3 hours

Sila pastikan bahawa kertas peperiksaan ini mengandungi LAPAN mukasurat dan LIMA soalan sebelum anda memulakan peperiksaan ini.

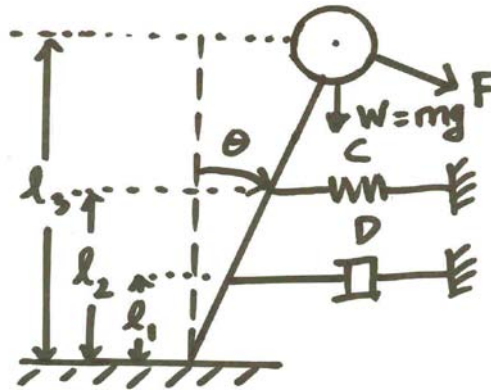
Please check that this examination paper consists of EIGHT printed pages and FIVE questions before you begin the examination.

Arahan: Jawab **EMPAT (4)** soalan.

Instructions : Answer **FOUR (4)** questions.

1. Pertimbangkan sistem bandul pegas terendam seperti dalam **Gambarajah 1** di bawah.

*Consider the damped spring pendulum system below in **Figure 1**.*



Gambarajah 1 : Sistem bandul pegas terendam dalam kedudukan terpesong

Figure 1 : Damped spring pendulum system in deflected position

Anggapkan bahawa daya pegas dan daya terendam yang bertindak ke atas bandul adalah sifar bila bandul berada dalam keadaan mendatar atau $\theta = 0$. Anggapkan juga bahawa geseran yang terlibat boleh diabaikan dan sudut ayunan θ adalah kecil.

Assume that the spring and damper force acting on the pendulum is zero when the pendulum is vertical or $\theta = 0$. Assume also that the friction involved is negligible and the angle of oscillation θ is small.

- (a) Dapatkan model matematik bagi sistem itu dalam bentuk

- (i) Persamaan perbezaan
- (ii) State Space Representation
- (iii) Fungsi pindah

Obtain the mathematical model of the system in form of

- (i) The differential equation
- (ii) State Space Representation
- (iii) Transfer function

(50 markah/marks)

- (b) Tetapkan parameter dinamik sistem frekuensi tabii (ω_o), nisbah redaman (ρ) dan frekuensi terendam (ω_d).

Determine dynamic parameter of the system natural frequency (ω_o), damping ratio (ρ) and damped frequency (ω_d).

(25 markah/marks)

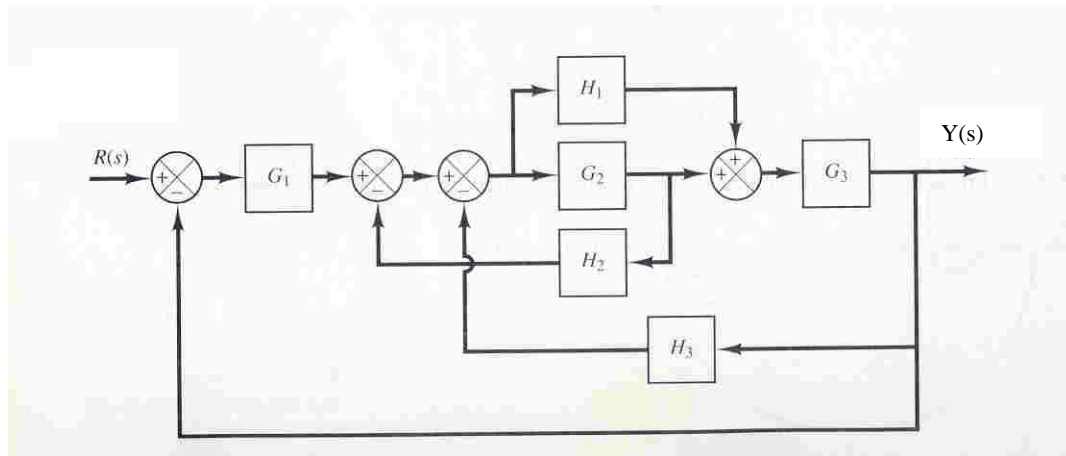
- (c) Sila ramalkan sambutan awal dan akhir sistem dengan menggunakan teori awal dan akhir.

Please predict the initial and stationary step-response using initial final theorems.

(25 markah/marks)

2. Dapatkan fungsi alih litar tertutup untuk blok diagram berikut:

(a)

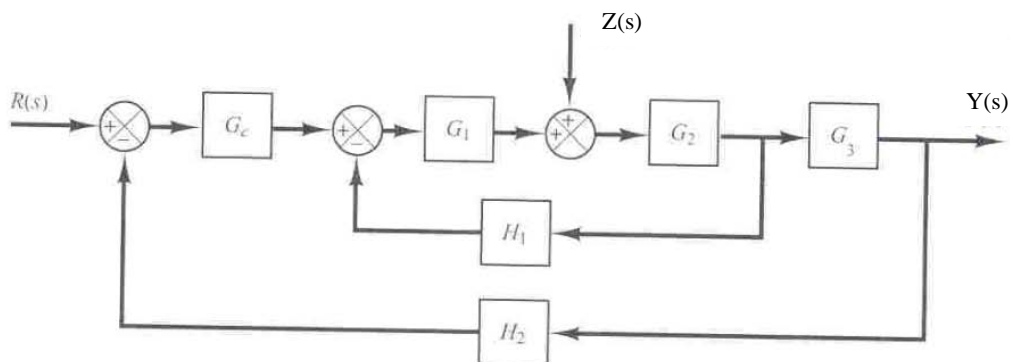


Gambarajah 2(a) : Block Diagram of Closed Loop 1

Figure 2 (a) : Block Diagram of Closed Loop 1

(40 markah/marks)

(b)

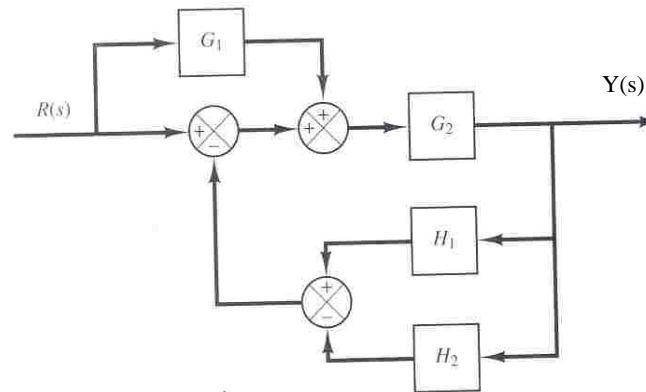


Gambarajah 2(b) : Block Diagram of Closed Loop System 2

Figure 2 (b) : Block Diagram of Closed Loop 2

(30 markah/marks)

(c)



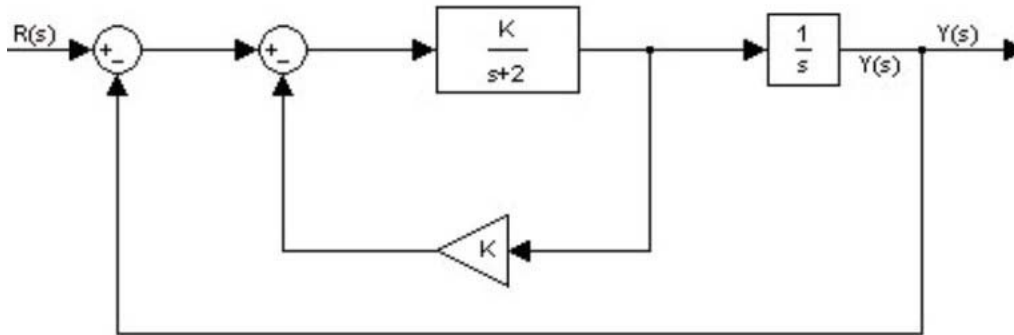
Gambarajah 2(c) : Block Diagram of Closed Loop System 3

Figure 2 (c) : Block Diagram of Close Loop System 3

(30 markah/marks)

3. Merujuk kepada sistem yang ditunjukkan dalam Gambarajah 3 di bawah:

Referring to the system shown in Figure 3 below:



Gambarajah 3 : Sistem Gelung Tertutup
Figure 3 : A Closed-Loop System

- (a) Tentukan nilai K_1 dan K_2 supaya sistem itu mempunyai nisbah redaman $\rho = 0.7$ dan frekuensi tabii tak terendam $W_o = 4 \text{ rad/sec}$.

Determine the values of K_1 and K_2 such that the system has a damping ratio $\rho = 0.7$ and undamped natural frequency $W_o = 4 \text{ rad/sec}$.

(50 markah/marks)

- (b) Dapatkan masa naik t_r , masa puncak t_p , maksimum terlajak M_p dan masa penganapan t_s dalam unit sambut langkah dan gambarkan/cantumkan masa-masa tersebut dalam lakaran unit sambutan langkah.

Obtain the rise time t_r , peak time t_p , maximum overshoot M_p , setting time t_s in the unit step response and put the times into the sketch of step response.

(50 markah/marks)

4. (a) Pertimbangkan persamaan ciri-ciri yang berikut:

$$S^4 + KS^3 + S^2 + S + 1 = 0$$

Tentukan julat K untuk kestabilan menggunakan Kriteria Routh.

Consider the following characteristic equation:

$$S^4 + KS^3 + S^2 + S + 1 = 0$$

Determine the range of K for stability using Routh's Criterion.

(50 markah/marks)

- (b) Pertimbangkan fungsi alih gelung terbuka

$$F_o(s) = \frac{K}{1 - TS} \quad ; K = 1.0$$

- (i) Lakarkan plot polar $F_o(s)$ di atas.
- (ii) Berdasarkan lakaran polar plot $F_o(s)$ di atas, tentukan sama ada belung tertutup $F_c(s)$ stabil atau tidak?.

Consider the open-loop transfer function

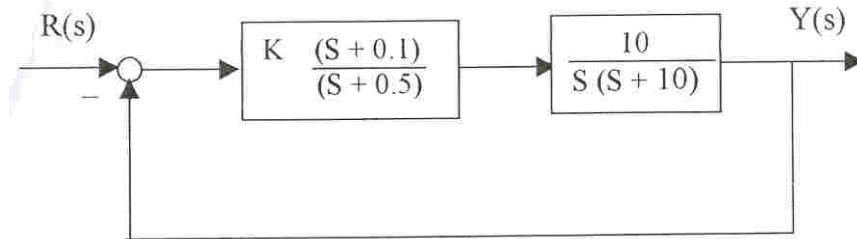
$$F_o(s) = \frac{K}{1 - TS} \quad ; K = 1.0$$

- (i) *Draw polar plot for $F_o(s)$ above.*
- (ii) *Based on polar plot $F_o(s)$, determine whether the closed loop $F_c(s)$ stable or not using nyquist-stability criterion?.*

(50 markah/marks)

5. Pertimbangkan sistem seperti yang ditunjukkan dalam Gambarajah 4.

Consider the system shown in Figure 4.



Gambarajah 4 : Rajah blok bagi penggerak hidraulik

Figure 4 : Block diagram of hydraulic servo actuator

- (a) Lukiskan rajah bode bagi fungsi pindah gelung terbuka.

Draw a bode diagram of open-loop transfer function.

(60 markah/marks)

- (b) Tentukan nilai gandaan K supaya margin fasa ialah 45°

Determine the value of gain K such that the phase margin is 45°

(20 markah/marks)

- (c) Apakah margin gandaan bagi sistem untuk gandaan K di atas.

What is the gain margin of the system with this gain K

(20 markah/marks)